INSTALLATION MANUAL

GEO DIRECT PWM AMPLIFIERS
PRELIMINARY DOCUMENTATION

Direct PWM

500-603700-xIxx

July 29, 2003

DELTA TAU
Data Systems, Inc.
NEW IDEAS IN MOTION ...

Single Source Machine Control *Power // Flexibility // Ease of Use*
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Safety Instructions

Qualified personnel must transport, assemble, install, and maintain this equipment. Properly qualified personnel are persons who are familiar with the transport, assembly, installation, and operation of equipment. The qualified personnel must know and observe the following standards and regulations:

IEC 364 resp. CENELEC HD 384 or DIN VDE 0100
IEC report 664 or DIN VDE 0110
National regulations for safety and accident prevention or VBG 4

Incorrect handling of products can result in injury and damage to persons and machinery. Strictly adhere to the installation instructions. Electrical safety is provided through a low-resistance earth connection. It is vital to ensure that all system components are connected to earth ground.

This product contains components that are sensitive to static electricity and can be damaged by incorrect handling. Avoid contact with high insulating materials (artificial fabrics, plastic film, etc.). Place the product on a conductive surface. Discharge any possible static electricity build-up by touching an unpainted, metal, grounded surface before touching the equipment.

Keep all covers and cabinet doors shut during operation. Be aware that during operation, the product has electrically charged components and hot surfaces. Control and power cables can carry a high voltage, even when the motor is not rotating. Never disconnect or connect the product while the power source is energized to avoid electric arcing.

After removing the power source from the equipment, wait at least 10 minutes before touching or disconnecting sections of the equipment that normally carry electrical charges (e.g., capacitors, contacts, screw connections). To be safe, measure the electrical contact points with a meter before touching the equipment.

The following text formats are used in this manual to indicate a potential for personal injury or equipment damage. Read the safety notices in this manual before attempting installation, operation, or maintenance to avoid serious bodily injury, damage to the equipment, or operational difficulty.

WARNING

A Warning identifies hazards that could result in personal injury or death. It precedes the discussion of interest.

CAUTION

A Caution identifies hazards that could result in equipment damage. It precedes the discussion of interest

Note

A Note identifies information critical to the user's understanding or use of the equipment. It follows the discussion of interest.

Standards

The GEO product series has been successfully tested and evaluated to meet UL/cUL 508C for U. S. and Canadian markets. These standards outline the minimum requirements for electrically operated power conversion equipment (frequency converters and servo amplifiers) and are intended to eliminate the risk of fire, electric shock, or injury to persons, being caused by such equipment.

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OVERVIEW

Delta Tau Data Systems' new family of servo amplifiers GEO Drives provide exciting new capabilities. This family of one axis and two axes 3-phase amplifiers can support a wide variety of motor types, power ranges, and interfaces. They will operate directly off the power mains (115- 480 VAC) for motor power and an external power supply of +24 volts DC for logic power.

New capabilities include:

- Versatile command format: Direct PWM, MACRO, ANALOG, or single-axis controller interface options allowing choice of centralized or distributed control-intelligence architectures.
- Dual axes product is both cost and size effective in multi-axes applications.
- Wide range of self-protection features.
- Easy setup with PMAC and UMAC controllers.
- Flexible OEM options, including special mounting options.
- Field bus interface options: DeviceNet or Profibus.
- Choice of input format supports both distributed and centralized control architects.

User Interface

The GEO Drive family is available in four basic interface versions, distinguished by their user interface styles. All versions have an on-board LED character status display, plus several discrete LED indicators.

- **Direct PWM** GEO Power Blocks (PWM) — In this version, the GEO drive accepts "direct PWM" signals from the controller, providing serial digital phase current feedback. This interface comes through a standard 36-pin Mini-D style connector, compatible with virtually all other power-block drives. In this form, the drive performs no control functions. It simply provides the raw power stage. No position feedback or I/O is connected to the drive (other than a power block thermal sensor and a possible motor thermal sensor). There is no connection to the controller other than the 36-pin cable, which brings in the PWM commands from the controller, and returns serial digital current values, as well as temperature data.
- **MACRO** — The GEO Drive interfaces to the controller through the fiber-optic MACRO 125 Mbit/sec ring, accepting numerical command values, and returning numerical feedback values over the ring. In one mode, the command values will be the 3-phase PWM values, making this drive the control-style equivalent of the Power Block. In other uses, the GEO Drive can be controlled in torque, velocity or even position modes. It can accept several styles of position feedback, including single or dual quadrature encoders, sinusoidal with built-in interpolation (x1024) in the GEO, resolvers, and absolute serial encoders (SSI, EnDat, Hiperface). It also provides interface for flags (limits and home), and some general-purpose I/O points. It passes the information from the position feedback flags and I/O back to the MACRO controller over the ring (even if it does not use this data itself).
- **Analog Drives** — The GEO Drive accepts a +/-10V analog command into a 16-bit A/D converter (or equivalent), representing either a velocity or a torque command. It can accept several styles of position feedback (Position feedback to the drive is required for commutation of a brushless motor.), including single or dual quadrature encoders, sinusoidal encoders with built-in interpolator (x1024), resolvers, and absolute serial encoders (SSI, EnDat, Hiperface). Regardless of the feedback type, it passes position information back to the controller as synthesized quadrature output

- **PMAC Drives** — The GEO Drive becomes a standalone-capable controller/drive with stored-program capability. It contains a "Micro PMAC" controller that provides a subset of PMAC capabilities with full positioning and trajectory capabilities, with synchronization to other drives and/or external encoders. It can accept several styles of position feedback, including single or dual quadrature encoders, sinusoidal encoders with interpolator, resolvers, and absolute serial encoders (SSI, EnDat, Hiperface). It also provides interface for flags (limits and home), and some general-purpose I/O points. Versions 2, 3 and 4 use a common logic PC Board platform.

- **Options** — Optionally, the Smart GEO Drive supports a built-in "Can-Bus" interface as well as Profibus and DeviceNet master or slave, and Field Bus I/O interfacing via a plug-in "SST" Universal Communications System (UCS) module.

A special UCS card has been designed to optionally provide USB (Universal Serial Bus) and Ethernet communications as well as additional I/O, a display driver connector, and two 20-point flat panel keyboard scanners.

Package Types

GEO package types provide various power levels and one or two axes capability. The GEO Drive has a basic package size of 3.3" W x 9.25" H x 8.125" D (84 mm W x 235 mm H x 206 mm D). This size includes the heat sink and fan. In this package size, the GEO can handle one or two low-to-medium power axes and only a single axis for medium to high power.

The mechanical design is such that it allows two heat sinks to be easily attached together so as to provide two high power axes in a double width configuration. This double package size is 6.6" W x 9.25" H x 8.125" D (168 mm W x 235 mm H x 206 mm D). It provides a highly efficient package size containing two axes of up to about 10kW each thus driving nearly 24kW of power, but using a single interface card. This results in a highly cost efficient package.

- **Flat Mounting Plate** (No Finned Heat Sink) **No Fan**
  3.3" wide (single width) (84 mm), Maximum Power Handling ~1200 watts
  Package Dimensions: 3.3" W x 9.25" H x 5.9" D (84 mm W x 235 mm H x 150 mm D)

- **Low Profile** (84 mm W x 235 mm H x 150 mm D)
  Finned Heat Sink, Black Anodized No Fan
  3.3" wide (single width) (168 mm), Maximum Power Handling ~2400 watts
  Package Dimensions: 3.3" W x 9.25" H x 8.125" D (84 mm W x 235 mm H x 206 mm D)

- **Finned Heat Sink, One Fan**
  3.3" wide (single width), Maximum Power Handling ~12,000 watts
  Package Dimensions: 3.3" W x 9.25" H x 8.125" D (84 mm W x 235 mm H x 206 mm D)

- **Finned Heat Sinks, Two Units, side by side Two Fans**
  6.6" wide (double width), Maximum Power Handling ~24,000 watts
  Package Dimensions: 6.6" W x 9.25" H x 8.125" D (168 mm W x 235 mm H x 206 mm D)

Compatible Motors

The GEO drive product line is capable of interfacing to a wide variety of motors. The GEO drive can control almost any type of three-phase brushless motors, including DC brushless rotary, AC brushless rotary, induction, and brushless linear motors. Motor selection for an application is a science in itself and cannot be covered in this manual. However, some basic considerations and guidelines are offered. Motor manufacturers include a host of parameters to describe their motor.

Some basic equations can help guide an applications engineer to mate a proper drive with a motor. A typical application accelerates a load to a speed, running the speed for a while and then decelerating the load back into position.

Feedback Devices

Many motors incorporate a position feedback device. Devices are incremental encoders, resolvers, and sine encoder systems. The direct PWM version of the GEO drive does not require feedback to it from the motor. The macro version of the GEO drive accepts feedback. In its standard form, it is set up to accept incremental encoder feedback. With the E option, it is possible to use either resolver or sinusoidal encoder feedback. Historically, the choice of a feedback device has been guided largely by cost and robustness. Today, feedbacks are relatively constant for the cost and picked for features such as size and feedback data. More feedback data or resolution provides the opportunity to have higher gains in a servo system.

Torque

The torque required for the application can be viewed as both instantaneous and average. Typically, the instantaneous or peak torque is calculated as a sum of machining forces or frictional forces plus the forces required to accelerate the load inertia. The machining or frictional forces on a machine must be determined by the actual application. The energy required to accelerate the inertia follows the equation: t = JA, where t is the torque in pound-feet required for the acceleration, J is the inertia in pound-feet-second squared, and A is in radians per second per second. When the desired acceleration rate and the load inertia reflected back to the motor are known, the required torque can be calculated. The t-JA equation requires that the motor's inertia be considered as part of the inertia-requiring torque to accelerate.

Once the torque is determined, the motor's specification sheet can be reviewed for its torque constant parameter (Kt). The torque required at the application divided by the Kt of the motor provides the peak current required by the amplifier. Again, a little extra room should be given to this parameter to allow for good servo control.

Most applications have a duty cycle in which the acceleration profile occurs repetitively over time. Calculating the average value of this profile gives the continuous rating required by the amplifier. Applications also concern themselves with the ability to achieve a speed. The requirements can be reviewed by either defining what the input voltage is to the drive, or defining what the voltage requirements are at the motor. Typically, a system is designed at a 230- or 480V input line. The motor must be able to achieve the desired speed with this voltage limitation. This can be determined by using the voltage constant of the motor (Kb), usually specified in volts-per-thousand rpm. The application speed is divided by 1000 and multiplied by the motor's Kb. This is the required voltage to drive the motor to the desired velocity. Again, 20% headroom is suggested to allow for good servo control.

Peak Torque

The peak torque rating of a motor is the maximum achievable output torque. It requires that the amplifier driving it be able to output enough current to achieve this. Many drive systems offer a 3:1 peak-to-continuous rating on the motor, while the amplifier has a 2:1 rating. To achieve the peak torque, the drive must be sized to be able to deliver the current to the motor. The required current is often stated on the datasheet as the peak current through the motor. In some sense, it can also be determined by dividing the peak amplifier's output rating by the motor's torque constant (Kt).

Continuous Torque

The continuous torque rating of the motor is defined by a thermal limit. If more torque is consumed from the motor than this on average, the motor overheats. Again, the continuous torque output of the motor is subject to the drive amplifier's ability to deliver that current. The current is determined by the manufacturer's datasheets stating the continuous RMS current rating of the motor and can also be determined by using the motor's Kt parameter, usually specified in torque output per amp of input current.

Motor Poles

Usually, the number of poles in the motor is not a concern to the actual application. However, it should be noted that each pole-pair of the motor requires an electrical cycle. High-speed motors with high motor pole counts can require high fundamental drive frequencies that a drive amplifier may or may not be able to output. In general, drive manufacturers with PWM switching frequencies (16kHz or below) would like to see commutation frequencies less than 400 Hz. The commutation frequency is directly related to the number of poles in the motor.

Motor Inductance

Typically, motor inductance of servomotors is 1 to 15 mH. The GEO drive product series can drive this range easily. On lower-inductance motors (below 1mH), problems occur due to PWM switching where heating currents flow through the motor, causing excessive energy waste and heating. If an application requires a motor of less than 1mH, external inductors are recommended to increase that inductance. Motors with inductance in excess of 15mH can still be driven, but are slow to react and typically are out of the range of high performance servomotors.

Motor Resistance

Motor resistance is not really a factor in determining the drive performance, but rather, comes into play more with the achievable torque or output horsepower from the motor. The basic resistance shows up in the manufacturer's motor horsepower curve.

Motor Back EMF

The back EMF of the motor is the voltage that it generates as it rotates. This voltage subtracts from the bus voltage of the drive and reduces the ability to push current through the motor. Typical back EMF ratings for servomotors are in the area of 8 to 200 volts-per-thousand rpm. The GEO drive product series can drive any range of back EMF motor, but the back EMF is highly related to the other parameters of the motor such as the motor inductance and the motor Kt. It is the back EMF of the motor that limits the maximum achievable speed and the maximum horsepower capability of the motor.

Motor Torque Constant

Motor torque constant is referred to as Kt and usually it is specified in torque-per-amp. It is this number that is most important for motor sizing. When the load that the motor will see and knowing the motor's torque constant is known, the drive amplifier requirements can be calculated to effectively size a drive amplifier for a given motor. Some motor designs allow Kt to be non-linear, in which Kt will actually produce less torque per unit of current at higher output speeds. It is wise to derate the systems torque producing capability by 20% to allow headroom for servo control.

Motor Inertia

Motor inertial comes into play with motor sizing because torque to accelerate the inertia of the motor is effectively wasted energy. Low inertia motors allow for quicker acceleration. However, consider the reflective inertia from the load back to the motor shaft when choosing the motor's inertial. A high ratio of load-to-motor inertia can cause limited gains in an application if there is compliance in the transmission system such as belt-drive systems or rubber-based couplings to the systems. The closer the rotor inertia matches the load's reflected inertia to the motor shaft, the higher the achievable gains will be for a given system. In general, the higher the motor inertia, the more stable the system will inherently be. Mechanical gearing is often placed between the load and the motor simply to reduce the reflected inertia back to the motor shaft.

Motor Cabling

Motor cables are an integral part of a motor drive system. Several factors should be considered when selecting motor cables. First, the PWM frequency of the drive emits electrical noise. Motor cables must have a good-quality shield around them. The motor frame must also have a separate conductor to bring back to the drive amplifier to help quench current flows from the motor due to the PWM switching noise. Both motor drain wire and the cable shield should be tied at both ends to the motor and to the drive amplifier.

Another consideration in selecting motor cables is the conductor-to-conductor capacitance rating of the cable. Small capacitance is desirable. Longer runs of motor cable can add motor capacitance loading to the drive amplifier causing undesired spikes of current. It can also cause couplings of the PWM noise into the earth grounds, causing excessive noise as well. Typical motor cable ratings would be 50 pf per foot maximum cable capacitance.

Another factor in picking motor cable is the actual conductor cross-sectional area. This refers to the conductor's ability to carry the required current to and from the motor. When calculating the required cable dimensions, consider the agency requirements, safety requirements, maximum temperature that the cable will be exposed to, the continuous current flow through the motor, and the peak current flow through the motor. Typically, it is not suggested that any motor cable be less than 14 AWG.

The motor cable’s length must be considered as part of the application. Motor cable length affects the system in two ways. First, additional length results in additional capacitive loading to the drive. The drive's capacitive loading should be kept to no more than 1000 pf. Additionally, the length sets up standing waves in the cable, which can cause excessive voltage at the motor terminals. Typical motor cable length runs of 200 feet for 230V systems and 50 feet for 480V systems are acceptable. Exceeding these lengths may put other system requirements in place for either a snubber at the motor end or a series inductor at the drive end. The series inductor at the drive end provides capacitance loading isolation from the drive and slows the rise time of the PWM signal into the cable, resulting in less voltage overshoot at the motor.

UNPACKING

Open the box and remove all the contents. Remove all packing material and equipment from the shipping container. Be aware that some connector kits and other equipment pieces may be quite small and can be accidentally discarded if care is not observed when unpacking the equipment. Do not dispose of shipping materials until the packing list has been checked.

Electronic components in this amplifier are design-hardened to reduce static sensitivity. However, proper procedures should be used when handling to avoid damage to equipment.

Upon receipt of the equipment, inspect components to ensure that no damage has occurred in shipment. If damage is detected, notify the carrier immediately. Check all shipping material for connector kits, documentation, diskettes, CD-ROM, or other small pieces of equipment.

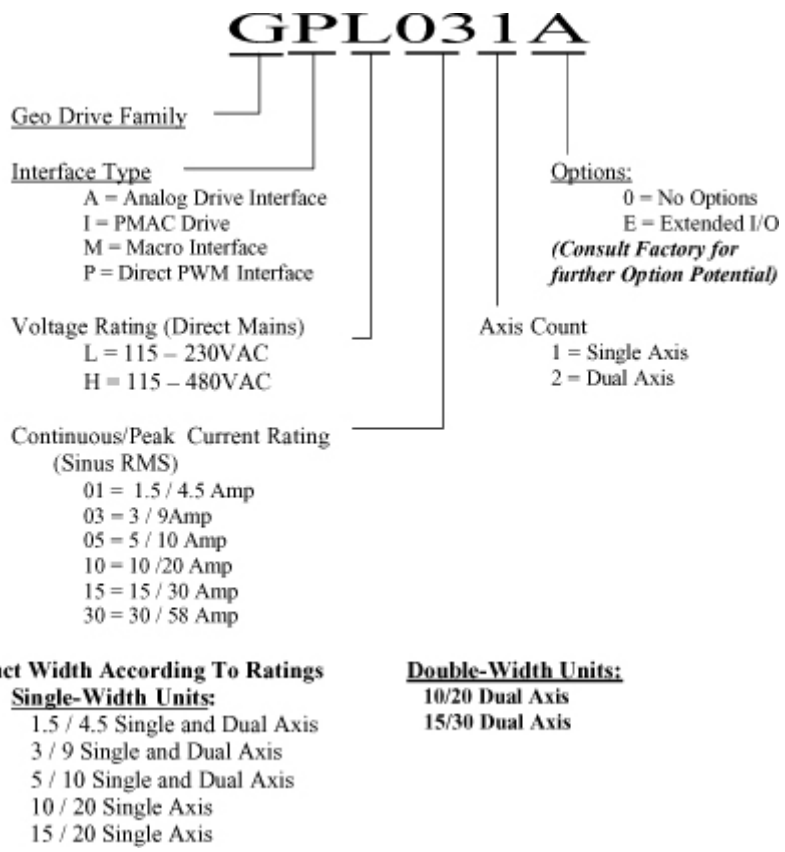
Use of Equipment

The following guidelines describe the restrictions for proper use of the GEO PWM:

- The components built into electrical equipment or machines can be used only as integral components of such equipment.
- The GEO Drives are to be used only on grounded three-phase industrial mains supply networks (TN-system, TT-system with earthed neutral point).
- The GEO Drives must not be operated on power supply networks without a ground or with an asymmetrical ground.
- If the GEO Drives are used in residential areas, or in business or commercial premises, the user must implement additional filter measures.
- The GEO Drives may only be operated in a closed switchgear cabinet, taking into account the ambient conditions defined in the environmental specifications.

Delta Tau Data Systems, Inc., guarantees the conformance of the GEO Drives with the standards for industrial areas stated in this manual, only if Delta Tau components (motors, cables, controllers, etc.) are used.

Part Number



Product Width According To Ratings

Single-Width Units:

1.5 / 4.5 Single and Dual Axis
3 / 9 Single and Dual Axis
5 / 10 Single and Dual Axis
10 / 20 Single Axis
15 / 20 Single Axis

Double-Width Units:

10/20 Dual Axis
15/30 Dual Axis

Hardware Specifications

Controller Model		GEO PWM	GEO 3U PWM
Unit Weight	lbs / Kgs	5.75 lbs.	3.5 lbs.
Mounting Hardware	English (Metric)	M (rack mount)	M (rack mount)
	Applied Torque		
Connection Hardware	Line Screw Size/Torque	N/A	#6
	Motor Screw Size/Torque		N/A
	Ground Screw Size/Torque		#10
Wire Size (AWG#)	Control Logic (AWG/ mm^2)	16	16
	Motor Line (AWG/ mm^2)	14	14
	Main Input (AWG/ mm^2)	12	12
	Configurable I/O wire gauge	22	N/A
	Spade Terminals	#10	#10
	Ring Terminals	#10	#10
Clearance Distance	Side-to-Side	3.5 inch	4-inch rack mount
	Top/Bottom	11.5 inch	5.05 inch rack mount

Electrical Specifications
(GxL012, GxL032, GxL052, GxL101, GxL151)

Product Model		GxL012	GxL032	GxL052	GxL101	GxL151
Main Input Power	Nominal Input Voltage (VAC)	230				
	Rated Input Voltage (VAC)	100-260				
	Rated Continuous Input Current (A AC_{RMS})	3.6	7.2	12	12	18
	Rated Input Power (KVA)	1.4	2.9	4.8	4.8	7.2
	Frequency (Hz)	50/60				
	Phase Requirements	1∅/3∅		3∅		
	Charge Peak Inrush Current (A)					
	Peak Line Current (A) for 2 Sec	9	18	20	20	30
	Main Bus Capacitance (µf)	2720				
	Mains Wire Gauge (AWG)	12				10
Output Power	Output Circuits (axis)	2			1	
	Rated Output Voltage (V)	230				
	Rated Cont. Output Current per Axis	1.5	3	5	10	15
	Peak Output Current (2s)	4.5	9	10	20	30
	Rated Output Power per Axis	0.6	1.2	2.0	4.0	6.0
Bus Protection	Nominal DC Bus	325				
	Over-voltage Trip Level (VDC)	415				
	Under-voltage Lockout Level (VDC)	10				
Shunt Regulator Ratings	Turn-On Voltage (VDC)	395				
	Turn-Off Voltage (VDC)	380				
	Maximum Current (A)	15				20
	Recommended Current (A)	9				
	Minimum Resistance (Ohms)	20				18
	Internal Capacitance (µf)	2720				
	Maximum Power (W)	500			750	
	Recommended Load Resistor (300 W Max.)	GAR48				
	Energy at Recommended Resistance (J)	3250				
Control Logic Power	Input Voltage (VDC)	20-27				
	Input Current (A)					
	Inrush Current (A)					
Current Sense Feedback	Resolution (bits)	12				
	Full-scale Signed Reading (±A)	8	16	18.3	36.6	54.9
	Maximum Offset (bits)					
	Maximum Noise					
Transistor Control	Maximum PWM Frequency (kHz)	16		12	16	12
	Minimum Dead Time (µs)	1				
	Charge Pump Time (% of PWM freq.)	17				

(GxH012, GxH032, GxH052, GxH101, GxH151)

Product Model		GxH012	GxH032	GxH052	GxH101	GxH151
Main Input Power	Nominal Input Voltage (VAC)	480				
	Rated Input Voltage (VAC)	100-525				
	Rated Continuous Input Current (A AC_{RMS})	3.6	7.2	12	12	18
	Rated Input Power (KVA)	3.0	6.0	10.0		14.9
	Frequency (Hz)	50/60				
	Phase Requirements	1∅/3∅		3∅		
	Charge Peak Inrush Current (A)					
	Peak Line Current (A) for 2 Sec	9	18	20	20	30
	Main Bus Capacitance (µf)	660				
	Mains Wire Gauge (AWG)	12				10
Output Power	Output Circuits (axis)	2			1	
	Rated Output Voltage (V)	480				
	Rated Cont. Output Current per Axis	1.5	3	5	10	15
	Peak Output Current (2s)	4.5	9	10	20	30
	Rated Output Power per Axis	1.2	2.5	4.2	8.3	12.5
Bus Protection	Nominal DC Bus	678				
	Over-voltage Trip Level (VDC)	828				
	Under-voltage Lockout Level (VDC)	20				
Shunt Regulator Ratings	Turn-On Voltage (VDC)	790				
	Turn-Off Voltage (VDC)	758				
	Maximum Current (A)	15				20
	Recommended Current (A)	10				16
	Minimum Resistance (Ohms)	40				35
	Internal Capacitance (µf)	660			940	
	Maximum Power (W)	500			750	
	Recommended Load Resistor (300 W Max.)	GAR78				
	Energy at Recommended Resistance (J)	8000				
Control Logic Power	Input Voltage (VDC)	20-27				
	Input Current (A)					
	Inrush Current (A)					
Current Sense Feedback	Resolution (bits)	12				
	Full-scale Signed Reading (±A)	8	16	18.3	36.6	54.9
	Maximum Offset (bits)					
	Maximum Noise					
Transistor Control	Maximum PWM Frequency (kHz)	12		10		8
	Minimum Dead Time (µs)	1.2				
	Charge Pump Time (% of PWM freq.)					

Recommended Fusing

Model	Recommended Fuse (FRN/LPN)	Recommended Wire Gauge*
GxL012x	20	12 AWG
GxL032x	25	10 AWG
GxL052x	20	12 AWG
GxL101x	20	12 AWG
GxL151x	25	10 AWG
GxH012x	10	14 AWG
GxH032x	15	12 AWG
GxH052x	20	12 AWG
GxH101x	20	12 AWG
GxH151x	25	10 AWG
* See local and national code requirements		

Mating Connector Kits

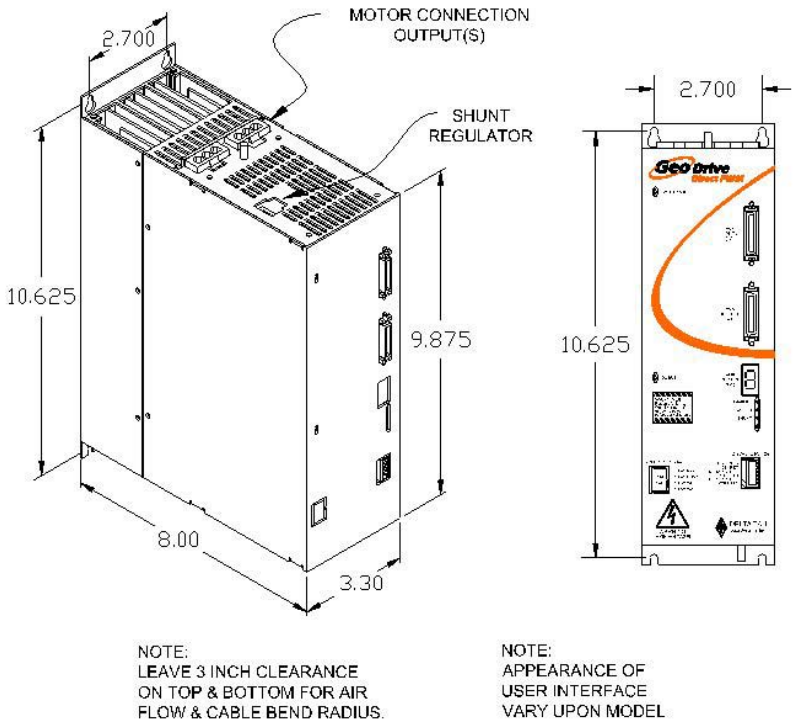
Connector Kit	Description
CONKIT1A	Mating Connector Kit for drives up to 5 amp continuous rating (Gxx012, Gxx032, Gxx052): Includes Molex Connectors kits for 2 motors, AC input connections, and 24V power connections. Requires Molex Crimp Tools for proper installation.
Molex Part #	63811-1500 for AC Input 63811-0400 for the Motor Output, 24V input
CONKIT1B	Includes Molex mating connectors pre-crimped for dual axis drives up to 5 amp continuous rated (Gxx012, Gxx032, Gxx052). The AC input and 24V have 3 ft. wires. The Motor connectors have 10 ft. shielded cable with exterminated end for motor connections.
CONKIT2A	Mating Connector Kit for drives up to 15 amp continuous rating (Gxx101, Gxx151): Includes Molex Connectors kits for 1 motor, AC input connections, and 24V power connections. Requires Molex Crimp Tools for proper installation.
Molex Part #	63811-1500 for AC input 63811-0400 for the motor output, 24V input, and Shunt Resistor
CONKIT1B	Includes Molex mating connectors pre-crimped for dual axis drives up to 15 amp continuous rated (Gxx101, Gxx151). The AC Input and 24V have 3 ft. wires. The Motor connector has 10 ft. shielded cable with exterminated end for motor connections.

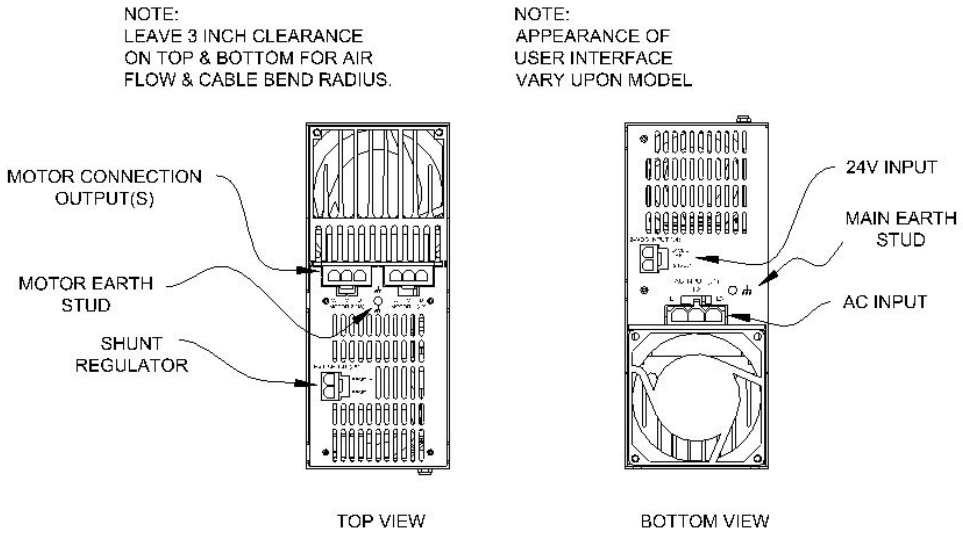
Note

Due to the variety, variations, and wide availability of D-type connectors and back shells, they are not provided in the connector kit.

MOUNTING

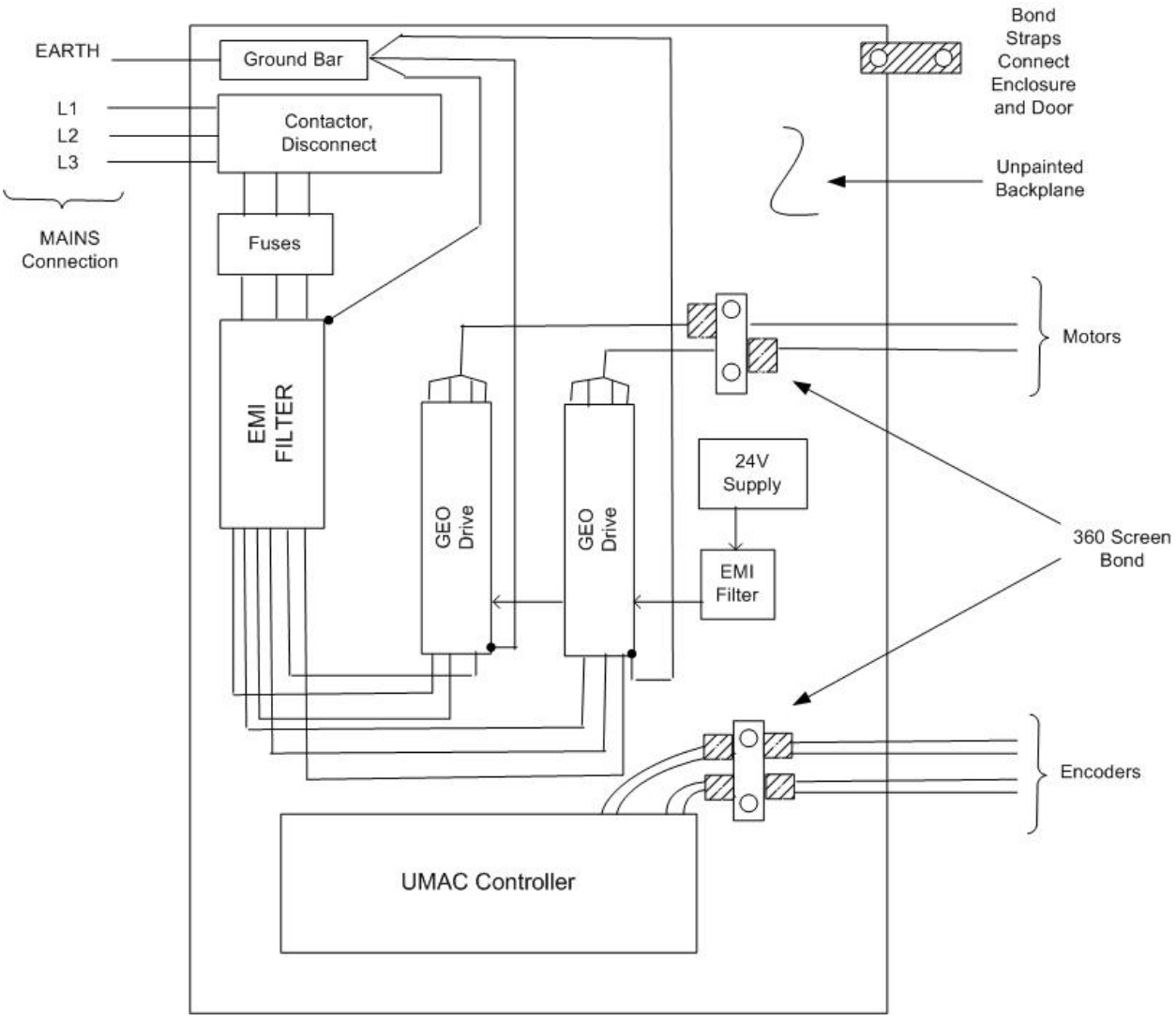
The GEO drive is installed in an enclosure whose ambient temperature does exceed 45 °C. It must not be exposed to conductive dust or humidity in excess of 90%. Corrosive gasses, corrosive dust, and other contaminants must be kept out of the drive enclosure. The figure below shows the mounting dimensions of the drive.





The drive is mounted to a back panel. The back panel should be unpainted and electrically conductive to allow for reduced electrical noise interference. The back panel is machined to accept the mounting bolt pattern of the drive, make sure that all metal chips are cleaned up before the drive is mounted so there is no risk of getting metal chips inside the drive.

The drive is mounted to the back panel with four M4 screws and internal-tooth lock washers. It is important that the teeth break through any anodization on the drive's mounting gears to provide a good electrically conductive path in as many places as possible. Mount the drive on the back panel so there is air flow at both the top and bottom areas of the drive (at least 3 inches). If multiple GEO drives are used, they can be mounted side-by-side, leaving at least one-tenth of an inch clearance between drives. It is extremely important that the air flow is not obstructed by the placement of conduit tracks or other devices in the enclosure.



Bonding

The proper bonding of shielded cables is imperative for minimizing noise emissions and increasing immunity levels. The bonding effect is to reduce the impedance between the cable shield and the back panel.

Power input wiring does not require shielding (screening) if the power is fed to the cabinet (enclosure) via metallized conduit. If metallized conduit is not used in the system, shielded cable is required on the power input wires along with proper bonding techniques.

Filtering

CE Filtering

The GEO Drive meets the CE Mark standards stated in the front of this manual. Apply proper bonding and grounding techniques, described earlier in this section, when incorporating EMC noise filtering components to meet this standard.

Noise currents often occur in two ways. The first is conducted emissions passed through ground loops. The quality of the system-grounding scheme inversely determines the noise amplitudes in the lines. These conducted emissions are of a common-mode nature from line-to-neutral (ground). The second is radiated high-frequency emissions that usually are capacitively coupled from line-to-line and are differential in nature.

When mounting the filters, make sure the enclosure has an unpainted metallic surface. This allows more surface area to be in contact with the filter housing and provide a lower impedance path between the housing and the back plane. The back panel should have a high frequency ground strap connection to the enclosure frame and earth ground.

Input Power Filtering

Caution

To avoid an electric shock, do not touch filters for at least 10 seconds after removing the power supply.

The Delta Tau Data Systems, Inc., GEO Drive electronic system components require EMI filtering in the input power leads to meet the conducted emission requirements for the industrial environment. This filtering blocks conducted-type emissions from exiting onto the power lines and provides a barrier for power line EMI.

Adequately size the system. The type of filter must be based on the voltage and current rating of the system and whether the incoming line is single- or three-phase. One input line filter may be used for multi-axis control applications. These filters should be mounted as close to the incoming power as possible so noise is not capacitively coupled into other signal leads and cables. Implement the EMI filter according to the following guidelines:

- Mount the filter as close as possible to incoming cabinet power.
- When mounting the filter to the panel, remove any paint or material covering. Use an unpainted metallic back panel, if possible.
- Filters are provided with an ground connection. All ground connections should be tied to earth.
- Filters can produce high leakage currents; they must be grounded before connecting the supply.
- Do not touch filters for a period of 10 seconds after removing the power supply.

Motor Line Filtering

Motor filtering may not be necessary for CE compliance of GEO Drives. However, this additional filtering increases the reliability of the system. Poor non-metallic enclosure surfaces and lengthy, unbonded (or unshielded) motor cables that couple noise line-to-line (differential) are some of the factors that may lead to the necessity of motor lead filtering.

Motor lead noise is either common-mode or differential. The common-mode conducted currents occur between each motor lead and ground (line-to-neutral). Differential radiated currents exist from one motor lead to another (line-to-line). The filtering of the lines feeding the motor provides additional attenuation of noise currents that may enter surrounding cables and equipment I/O ports in close proximity.

Differential mode currents commonly occur with lengthy motor cables. As the cable length increases, so does its capacitance and ability to couple noise from line-to-line. While every final system is different and every application of the product causes a slightly different emission profile, it may become necessary to use differential mode chokes to provide additional noise attenuation to minimize the radiated emissions. The use of a ferrite core placed at the GEO Drive end on each motor lead attenuates differential mode noise and lowers frequency (30 to 60 MHz) broadband emissions to within specifications. Delta Tau Data Systems, Inc., recommends a Fair-Rite P/N 263665702 (or equivalent) ferrite core.

Common mode currents occur from noise spikes created by the PWM switching frequency of the GEO Drive. The use of a ferrite or iron-powder core toroid places common mode impedance in the line between the motor and the GEO Drive. The use of a common mode choke on the motor leads may increase signal integrity of encoder outputs and associated I/O signals.

I/O Filtering

I/O filtering may be desired, depending on system installation, application, and integration with other equipment. It may be necessary to place ferrite cores on I/O lines to avoid unwanted signals entering and disturbing the GEO.

The GEO drives can be mounted three different ways:

1. Traditional 4-hole panel mount, two “U shape”/notches on the bottom and two pear shaped holes on top. This method keeps the heat sink and fan, if used, inside the mounting enclosure.

   This method allows for side-by-side mounting of the single width GEO Amps at 3.4 center-to-center distance (86 mm). Double width GEO amplifiers mount side by side at 6.7 inch center-to-center distance (171 mm).

2. A “Through the Panel” mount which requires a hole in the mounting cabinet so that the GEO heat sink can protrude through the mounting enclosure in order to vent the heat outside the enclosure. A special “Skirt” with gasket seal is provided for this purpose. Mounting hole pattern is the same as the traditional mounting for four holes with two additional holes added on the sides.

   This method requires clearance for the mounting “skirt.” Single width center-to-center mounting distance is 4.3 (109mm). Double-width GEO amplifiers have a center-to-center distance of 7.6 inches (193 mm).

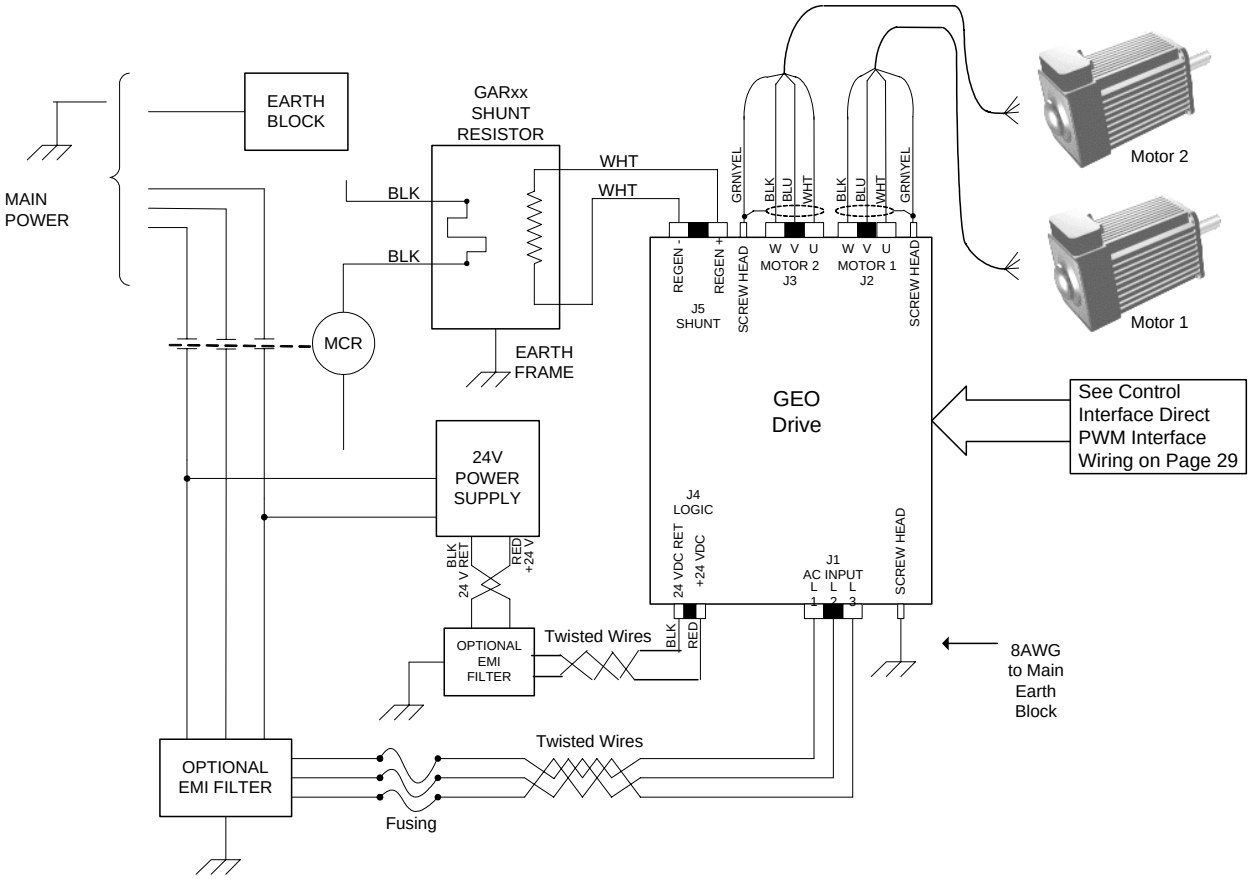
3. The third method actually removes the heat sink and replaces it with a flat plate, which has no fan, and uses the mounting enclosure itself as a heat sink and reduces the depth of the GEO amplifier by about 2.2 inches (~56 mm) to a slim 5.9 inch D (150 mm D). Mounting is also identical to the first method.

   This method allows for side-by-side mounting of the single width GEO Amps at 3.4 center-to-center distance (86 mm). Double-width GEO amplifiers mount side by side at 6.7 inch center-to-center distance (171 mm).

SYSTEM WIRING

Caution

Units must be installed in an enclosure that meets the environmental IP rating of the end product (ventilation or cooling may be necessary to prevent enclosure ambient from exceeding 113° F [45° C]).



WARNING

Installation of electrical control equipment is subject to many regulations including national, state, local, and industry guidelines and rules. General recommendations can be stated but it is important that the installation be carried out in accordance with all regulations pertaining to the installation.

Wire Sizes

Drive electronics create a DC bus by rectifying the incoming AC electricity. The current flow into the drive is not sinusoidal but rather a series of narrow, high-peak pulses. Keep the incoming impedance small to not hinder these current pulses. Conductor size, transformer size, and fuse size recommendations may seem larger than normally expected. All ground conductors should be 8AWG minimum using wires constructed of many strands of small gauge wire. This provides the lowest impedance to high-frequency noises.

Fuse and Circuit Breaker Selection

In general, fusing must be designed to protect the weakest link from fire hazard. Each Geo drive is designed to accept more than the recommended fuse ratings. External wiring to the drive may be the weakest link as its routing is less controlled than the drive's internal electronics. Therefore, external circuit protection, be it fuses or circuit breakers, must be designed to protect the lesser of the drive or external wiring.

High peak currents and high inrush currents demand the use of slow blow type fuses and hamper the use of circuit breakers with magnetic trip mechanisms. Generally, fuses are recommended to be larger than what the rms current ratings require. Remember that some drives allow three times the continuous rated current on up to two axis of motion. Time delay and overload rating of protection devices must consider this operation.

Use of GFI Breakers

Ground Fault Interrupter circuit breakers are designed to break the power circuit in the event that not all outgoing currents can be accounted for by the returning currents. These breakers assume that if outgoing currents are not returning then there is a short circuit at the load. Most circuit breakers of this type account for currents as low as 10mA. This operation is problematic when used with PWM drive technology. The PWM switching allows parasitic leakage currents to flow into the ground system in the motor cable and the motor frame. Careful installation practices must be followed. The use of inductor chokes in the output leads of the drive is often required to keep these leakage currents below a few hundred milliamps. Normally the use of GFI breakers is not recommended because of these problems. Adjustment of a GFI breaker may be necessary.

Transformer and Filter Sizing

Incoming power design considerations for use with Geo Drives require some over rating. In general, it is recommended that all 3-phase systems using transformers and incoming filter chokes be allotted a 25% over size to keep the impedances of these inserted devices from affecting stated system performance. In general, it is recommended that all single-phase systems up to 1kW be designed for a 50% overload. All single-phase systems over 1kW should be designed for a 200% overload capacity.

Noise Problems

When problems do occur often it points to electrical noise as the source of the problem. When this occurs, turn to controlling high-frequency current paths. If following the grounding instructions does not work, insert chokes in the motor phases. These chokes can be as simple as several wraps of the individual motor leads through a ferrite ring core (such as Micrometals T400-26D). This adds high-frequency impedance to the outgoing motor cable thereby making it harder for high-frequency noise to leave the control cabinet area. Care should be taken to be certain that the core's temperature is in a reasonable range after installing such devices.

Operating Temperature

It is important that the ambient operating temperature of the Geo Drive be kept within specifications. The Geo Drive is installed in an enclosure such as a NEMA cabinet. The internal temperature of the cabinet must be kept under the Geo Drive Ambient Temperature specifications. It is sometimes desirable to roughly calculate the heat generated by the devices in the cabinet to determine if some type of ventilation or air conditioning is required. For these calculations the Geo Drive's internal heat losses must be known. Budget 100W per axis for 1.5 amp drives, 150W per axis for 3 amp drives, 200W per axis for 5 amp drives, 375W per axis for 10 Amp drives, and 500W per axis for 15 Amp drives.

Single Phase Operation

Due to the nature of power transfer physics, it is not recommended that any system design attempt to consume more than 2kW from any single-phase mains supply. Even this level requires careful considerations. The simple bridge rectifier front end of the Geo Drive, as with all other drives of this type, require high peak currents. Attempting to transfer power from a single-phase system getting one charging pulse each 8.3 milliseconds causes excessively high peak currents that can be limited by power mains impedances. The Geo Drive output voltage sags, the input rectifiers are stressed, and these current pulses cause power quality problems in other equipment connected to the same line. While it is possible to operate drives on single-phase power, the actual power delivered to the motor must be considered. Never design expecting more than 1.5 HP total from any 115V single-phase system and never more than 2.5 HP from any 230V single-phase system.

Wiring AC Input

The main bus voltage supply is brought to the GEO drive through connector J1. 1.5 amp continuous and 3 amp continuous GEO drives can be run off single-phase power. It is acceptable to bring the single-phase power into any two of the three input pins on connector J1. If not using one of the terminals, place a wire jumper from the third terminal to one of the other two.

Higher-power drive amplifiers require three-phase input power. It is extremely important to provide fuse protection or over-load protection to the input power to the GEO drive amplifier. Typically, this is provided with fuses designed to be slow acting, such as FRN-type fuses. Due to the various regulations of local codes, NEC codes, UL and CE requirements, it is very important to reference these requirements before making a determination of how the input power is wired.

Additionally, many systems require that the power be able to be turned on and off in the cabinet. It is typical that the AC power is run through some kind of main control contact within the cabinet, through the fuses, and then fed to a GEO drive. If multiple GEO drives are used, it is important that each drive has its own separate fuse block.

Whether single- or three-phase, it is important that the AC input wires be twisted together to eliminate noise radiation as much as possible. Additionally, some applications may have further agency noise reduction requirements that require that these lines be fed from an input filtering network.

The AC connections from the fuse block to the GEO drive are made via a cable that is either purchased as an option from Delta Tau (CONKIT1 or CONKIT1A) or the terminations to the connector may be made as shown in Appendix A.

AC Input Connector Pin Out

Pin #	Symbol	Function	Description	Notes
1	L3	Input	Depending on model	40VAC to 480VAC
2/3	L2	Input	Depending on model	Depending on type
4	L1	Input	Depending on model	

Wiring Earth-Ground

Panel wiring requires that a central earth-ground location be installed at one part of the panel. This electrical ground connection allows for each device within the enclosure to have a separate wire brought back to the central wire location. The ground connection is usually a copper plate directly bonded to the back panel or an aluminum strip with multiple screw locations. The GEO drive is brought to the earth-ground via a wire connected to the M4 stud on the top of the location through a heavy gauge, multi-strand conductor to the central earth-ground location. The nut on the stud should be tightened to 5 inch-pounds.

Earth Grounding Paths

High-frequency noises from the PWM controlled power stage will find a path back to the drive. It is best that the path for the high-frequency noises be controlled by careful installation practices. The major failure in problematic installations is the failure to recognize that wire conductors have impedances at high frequencies. What reads 0 ohms on a DVM may be hundreds of ohms at 30MHz. Consider the following during installation planning:

1. Star point all ground connections. Each device wired to earth ground should have its own conductor brought directly back to the central earth ground plate.
2. Use unpainted back panels. This allows a wide area of contact for all metallic surfaces reducing high frequency impedances.
3. Conductors made up of many strands of fine conducts outperform solid or conductors with few strands at high frequencies.
4. Motor cable shields should be bounded to the back panel using 360-degree clamps at the point they enter or exit the panel.
5. Motor shields are best grounded at both ends of the cable. Again, connectors using 360-degree shield clamps are superior to connector designs transporting the shield through a single pin. Always use metal shells.
6. Running motor armature cables with any other cable in a tray or conduit should be avoided. These cables can radiate high frequency noise and couple into other circuits.

Wiring 24V Logic Control

An external 24Vdc power supply is required to power the logic portion of the GEO drive. This power can remain on, regardless of the main AC input power, allowing the signal electronics to be active while the main motor power control is inactive. The 24V is wired into connector J4. The polarity of this connection is extremely important. Carefully follow the instructions in the wiring diagram. This connection can be made using 16 AWG wire directly from a protected power supply. In situations where the power supply is shared with other devices, it may be desirable to insert a filter in this connection.

The power supply providing these 24 volts must be capable of providing an instantaneous current of at least 1.5 amps to be able to start the DC-to-DC converter in the GEO drive. In the case where multiple drives are driven from the same 24V supply, it is recommended that each drive be wired back to the power supply terminals independently. It is also recommended that the power supply be sized to handle the instantaneous inrush current required to start up the DC-to-DC converter in the GEO drive.

24V Logic Supply Connector Pin Out

Pin #	Symbol	Function	Description	Notes
1	24V RTN	Common	Control power return	
2	24V	Input	Control power input	24V+/-10% 3 Amp

Wiring the Motors

The cable wiring must be shielded and have a separate conductor connecting the motor frame back to the drive amplifier. The cables are available in connector kits (CONKIT1 or CONKIT1A) from Delta Tau or the terminations can be made as described in Appendix A.

Motor phases are conversed in one of three conventions. Motor manufacturers will call the motor phases A, B, or C. Other motor manufacturers call them U, V, W. Induction motor manufacturers may call them L1, L2, and L3. The drive's inputs are called U, V, and W. Wire U, A, or L1 to the drive's U terminal. Wire V, B, or L2 to the drive's V terminal. Wire W, C, or L3 to the drive's W terminal.

The motor's frame drain wire and the motor cable shield must be tied together at the mounting stud on top of the GEO drive product. Tighten the nuts to 5 inch-pounds.

AXIS MTR Output Connector Pin Out

Pin #	Symbol	Function	Description	Notes
1	U Phase1	Output	Axis 1	
2	V Phase2	Output	Axis 1	
3	W Phase3	Output	Axis 1	

AXIS 2 Motor Out Connector Pin Out

Pin #	Symbol	Function	Description	Notes
1	U Phase2	Output	Axis 2	2- Axis drives only
2	V Phase2	Output	Axis 2	2- Axis drives only
3	W Phase2	Output	Axis 2	2- Axis drives only

Wiring the Motor Thermostats

Some motor manufacturers provide the motors with integrated thermostat overload detection capability. Typically, it is in one or two forms: a contact switch that is normally closed or a PTC. These sensors can be wired into the GEO drive's front panel at connector X3. Motor 1 is wired to Motor1 PTC return and Motor1 PTC. These contacts have to be low impedance for the drive to be operational. Motor 2 can be wired to Motor2 PTC return or thermostat switch can be wired to red MTR2 PTC return and MTR R2 return. If the motor overload protection is not required, these inputs can be jumpered together to disable this function in the drive. The connection of these signals to the Geo Drive is dependent on the MACRO or PWM versions.

Regen (Shunt) Resistor Wiring

The Geo Drive family offers compatible regen resistors as optional equipment. The regen resistor is used as a shunt regulator to dump excess power during demanding deceleration profiles. The GAR48 and GAR78 resistors are designed to dump the excess bus energy very quickly.

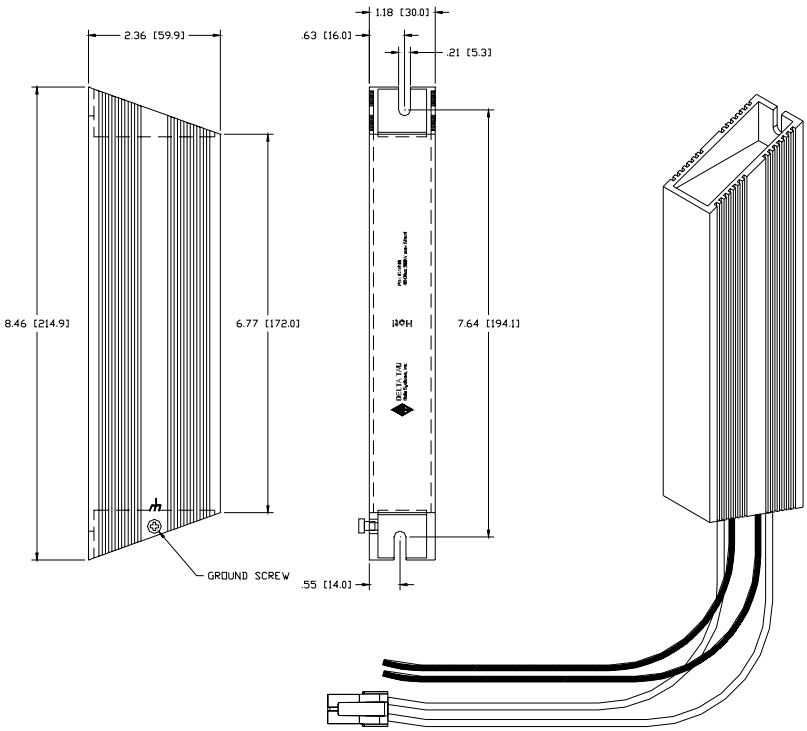
The regen circuit is also known as a shunt regulator. Its purpose is to dump power fed back into the drive from a motor acting as a generator. Excessive energy can be dumped via an external load resistor. The GEO product series is designed for operation with external shunt resistors of 48 Ω for the 10 and 15 amp versions or 78 Ω for the 1.5, 3, and 5 amp versions. These are available directly from Delta Tau as GAR48 and GAR78, respectively. These resistors are provided with pre-terminated cables that plug into connector J5.

Each resistor is the lowest ohm rating for its compatible drive and is limited for use to 200 watts RMS. There are times the regen design might be analyzed to determine if an external Regen resistor is required or what its ratings can be. The following data is provided for such purpose.

Caution

The black wires are for the thermostat and the white wires are for the regen resistor on the external regen resistor (pictured above). These resistors can get very hot. It is recommended that they be mounted away from other devices and near the top of the cabinet.

The regen resistors incorporate a thermal overload protection device available through the two black leads exiting the resistor. It is important that these two leads be wired in a safety circuit that stops the system from operating should the thermostat open.



Ext. Shunt Connector Pin Out

Pin #	Symbol	Function
1	Ext regen+	Output
2	Ext regen-	Output

Shunt Regulation

When the motor is used to slow the moving load, this is called regenerative deceleration. Under this operation, the motor is acting as a generator consuming energy from the load while passing the energy into the DC Bus storage capacitors. Left unchecked, the DC Bus voltage can raise high enough to damage the drive. For this reason there are protection mechanisms built into the Geo Drive product such as shunt regulation and over-voltage protection.

The shunt regulator monitors the DC Bus voltage. If this voltage rises above a present threshold (Regen Turn On Voltage), the Geo Drive will turn on a power device intended to place the externally mounted regen resistor across the bus to dump the excessive energy. The power device keeps the regen resistor connected across the bus until the bus voltage is sensed to be below the Regen Turn Off voltage at which time the power device removes the resistor connection.

Minimum Resistance Value

The regen resistor selection requires that the resistance value of the selected resistor will not allow more current to flow through the Geo Drive's power device than specified.

Maximum Resistance Value

The maximum resistor value that will be acceptable in an application is one that will not let the bus voltage reach the drive's stated over voltage specification during the deceleration ramp time. The following equations defining energy transfer can be used to determine the maximum resistance value.

Energy Transfer Equations

Regen, or shunt, regulation analysis requires study of the energy transferred during the deceleration profile. The basic philosophy can be described as follows:

- The load has stored energy in its rotating mass.
- The drive removes this energy by transferring it to the DC Bus.
- There are significant energy losses in the transfer, both electrical and mechanical.
- The DC Bus capacitors can store some energy.
- The remaining energy, if any, is transferred to the regen resistor.

Understanding this process in all its individual parts, it is possible to analyze the shunt regulator circuitry in more detail.

Energy Stored in the Load

Energy stored in the moving mass is a function of inertia and velocity according to the equation:

$$e_L = 0.678\, j\varpi^2$$

Where:

J is the total system inertia (including motor) in $lbftsec^2$
ω is the velocity of the motor in Radians per Second
e_L is the stored energy, in Joules (watt-seconds), of the load

Energy Loss in Transmission

The energy loss in the transmission of the energy occurs in two distinctive areas. First, the motor's resistance burns energy in simple watts. Second the mechanical gearing, bearings, and linkages present a frictional loss. The motor's resistive losses can be calculated for a linear deceleration profile as follows:

$$e_{xr} = \frac{3}{2} i * r_{phase} * t_d$$

Where:

i is the current used during deceleration in amperes
r_{phase} is the motor's resistance phase-to-phase in ohms
t_d is the time duration of the deceleration profile in seconds
e_{xr} is the lost energy in Joules (watt-seconds)

The mechanical transmission energy losses can be calculated as follows:

$$e_{xm} = 0.678 i * T_{friction} * \omega * t_d$$

Where:

$T_{friction}$ is the total friction in $lbftsec^2$
ω is the velocity of the motor in Radians per Second
e_{xm} is the mechanical energy loss in Joules (watt-seconds)
t_d is the time duration of the deceleration profile in seconds

Energy Stored in the Drive

Not all regenerative energy is spent in the resistive dump process. The drive has bus capacitors capable of storing some of the returned energy. This energy storage is calculated using the following equation:

$$e_c = \frac{1}{2} c \left(v_1^{\,2} - v_2^{\,2} \right)$$

Where:

C is the total bus capacitance in the drive in Farads
V_1 is the Bus Voltage at which Regen turns on
V_2 is the nominal bus voltage
e_c is the energy stored in Joules (Watt-Seconds)

Need for Regen Resistor

Any energy that is not lost in the transmission of the energy and cannot be stored by the bus capacitors must be dumped by the Regen circuits into the regen resistor. The following equation summarizes the energy flow:

$$e_{excess} = e_1 - e_{xr} - e_{xm} - e_c$$

Phrase this slightly differently and it can be stated that if e_{excess} is less than or equal to 0 there is no need to use an external Regen Resistor.

Regen Resistor Wattage

Converting this energy into wattage can allow the rating of the regen resistor to be analyzed. The unit of Joule is converted to wattage by dividing by the duty cycle of the overall motion profile.

$$Watts_{rms} = \frac{e_{excess}}{t_d}$$

Where:

T_d is the motion profile duty cycle, in seconds.

The peak wattage rating of the regen resistor is determined simply by dividing the square of the DC bus overage specification by the resistors ohm value:

$$Watts_{Peak} = \frac{V_{ov}^{2}}{R}$$

DIRECT PWM COMMUTATION CONTROLLER SETUP

The 3U amplifier must have the proper controller setup to command the amplifier/motor system. This section summarizes the key variables of both Turbo and Non Turbo PMAC2 controllers that would have to be modified for use with the amplifier. The Delta Tau setup software such as Turbo Setup will help set these parameters for the system automatically. For details about direct commutation of brushless and induction motors, read the User Manual for either the PMAC2 or Turbo PMAC2. To find out the details about these variables, refer to the Software Reference Manual for PMAC2 or Turbo PMAC2.

Key Servo IC Variables

Non Turbo	Turbo	Type	Description
I900	I7m00	Clock	Max phase clock setting
I901	I7m01	Clock Divisor	Phase clock divisor
I902	I7m02	Clock Divisor	Servo clock divisor
I903	I7m03	Clock	Hardware clock settings
I904	I7m04	Clock	PWM dead time
I905	I7m05	Strobe	DAC strobe word
*	I7m06	Strobe	ADC strobe word (Must be set to $3FFFFF for Amplifiers.)
I9n0	I7mn0	Channel	Encoder decode for channel
I9n6	I7mn6	Channel	Output mode for channel (Must be set to 0.)
* To change the ADC strobe word for a non-Turbo PMAC2 controller, issue a write command directly to the memory location of the Gate array channel connected to the amplifier. For non-Turbo PMAC2 channel 1-4, use memory location X:$C014. For non-Turbo PMAC2 channel 5-8, use memory location X:$C024. For example: `WX$C014,$3FFFFF.`			

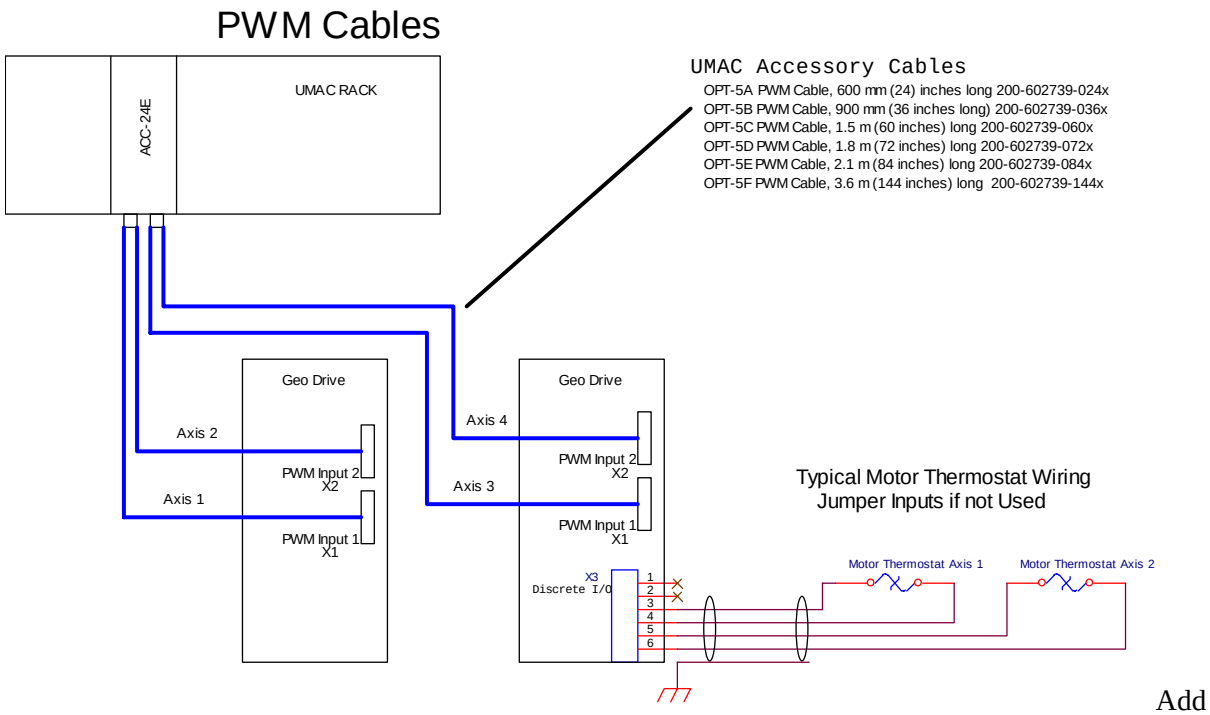
Key Motor Variables

CAUTION

The ADC Strobe Word, I7m06, must be set to $3FFFFF for proper operation. Failure to set I7m06 equal to $3FFFFF could result in damage to the amplifier.

Non Turbo	Turbo	Type	Description
Ix00	Ixx00	General	Motor enable
Ix01	Ixx01	General	Commutation enable
Ix25	Ixx24 Ixx25	General	Motor flag setup
Ix70	Ixx70	Commutation	Number of commutation cycles per Ix71
Ix71	Ixx71	Commutation	Counts per commutation cycle per Ix70
Ix72	Ixx72	Commutation	Commutation phase angle
Ix77	Ixx77	Commutation	Induction motor magnetization current
Ix78	Ixx78	Commutation	Induction motor slip gain
Ix83	Ixx83	Commutation	On-going phase position
Ix61	Ix61	Current Loop	Current loop integrator gain
Ix62	Ix62	Current Loop	Current loop forward path proportional gain
Ix66	Ix66	Current Loop	PWM scale factor
Ix76	Ix76	Current Loop	Current loop back bath proportional gain
Ix82	Ix82	Current Loop	Current loop feedback address
Ix84	Ix84	Current Loop	Current loop feedback ADC mask word
Ix57	Ixx57	I^2T	Continuous limit for I2T
Ix58	Ixx58	I^2T	Integrated current limit

DIRECT PWM INTERFACE WIRING



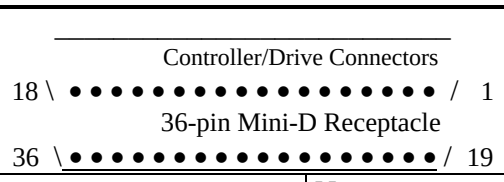
Add

I/O Terminal Block (6-Point) [PWM Only]

For Power-Block PWM Drives only.

Pin #	Symbol	Function	Description
1	MTR1 PTC	Input	Motor thermal
2	MTR 1 PTC RET		
3	MTR2 PTC	Input	Motor thermal
4	MTR2 PTC RTN		
5	FIELD GND		
6	N.C.		

PWM Input 1 PWM 1 (36-Pin Mini-D Connector)

36-Pin Mini-D Connector				
Pin#	**Symbol**	**Function**	**Description**	**Notes**
1	Reserved			
2	Reserved			
3	ADC_CLK1+	Command	A/D converter clock	
4	ADC_STB1+	Command	A/D converter strobe	
5	CURRENTA+	Feedback	Phase A actual current data	Serial digital
6	CURRENTB+	Feedback	Phase B actual current data	Serial digital
7	AENA1+	Command	Amplifier enable	High is enable
8	FAULT1+	Feedback	Amplifier fault	High is fault
9	PWMATOP1+	Command	Phase A top cmd	High is on command
10	PWMABOT1+	Command	Phase A bottom cmd	High is on command
11	PWMBTOP1+	Command	Phase B top cmd	High is on command
12	PWMBBOT1+	Command	Phase B bottom cmd	High is on command
13	PWMCTOP1+	Command	Phase C top cmd	High is on command
14	PWMCBOT1+	Command	Phase C bottom cmd	High is on command
15	GND	Common	Reference voltage	
16	+5V	Power	+5V Power	From controller
17	Reserved			
18	Reserved			
19	Reserved			
20	Reserved			
21	ADC_CLK1-	Command	A/D converter clock	
22	ADC_STB1-	Command	A/D converter strobe	
23	CURRENTA-	Feedback	Phase A actual current DATA	Serial digital
24	CURRENTB-	Feedback	Phase B actual current DATA	Serial digital
25	AENA1-	Command	Amplifier enable	Low is enable
26	FAULT1-	Feedback	Amplifier fault	Low is fault
27	PWMATOP1-	Command	**Phase A top cmd**	Low is on command
28	PWMABOT1-	Command	Phase A bottom cmd	Low is on command
29	PWMBTOP1-	Command	Phase B top cmd	Low is on command
30	PWMBBOT1-	Command	Phase B bottom cmd	Low is on command
31	PWMCTOP1-	Command	Phase C top cmd	Low is on command
32	PWMCBOT1-	Command	Phase C bottom cmd	Low is on command
33	GND	Common	Reference Voltage	
34	+5V	Power	+5V Power	From controller
35	Reserved			
36	Reserved			

SETTING I^2T PROTECTION

It is very important to set the I^2T protection for the amplifier/motor system for PMAC2 direct PWM commutation. Normally, an amplifier has internal I^2T protection because it is closing the current loop. When PMAC2 is closing the current loop, the amplifier cannot protect itself or the motor from over heating. Either set up the I^2T protection using one of the Setup Programs or manually set the Ixx69, Ixx57 and Ixx58 variables based on the following specifications:

Parameter	Description	Notes
MAX ADC Value	Maximum Current output of amplifier relative to a value of 32767 in Ixx69	Part of amplifier specification
Instantaneous Current Limit	The lower of the amplifier or motor system	RMS or Peak*
Continuous Current Limit	The lower of the amplifier or motor system	Usually RMS
I^2T protection time	Time at instantaneous limit	Usually two seconds
Magnetization Current	Ixx77 value for induction motors	Only for induction motors
Servo Update Frequency	Default is 2258 Hz.	
* If specification given in RMS, calculate this value by 1.41 to obtain peak current for calculations.		

Example Calculations for Direct PWM commutated motor:

MAX ADC = 18A

Instantaneous Current Limit = 18A Peak

Continuous Current Limit = 7A RMS

I^2T protection time = 2 seconds

Magnetization Current (Ixx77) = 0

Servo Update = 2.258 kHz

$$Ixx69 = \frac{Instaneous\ Limit(\ Peak\ )}{MAX\ \ ADC}\ x32767$$

if calculated Ixx69>32767 then Ixx69 equals 32767

$$Ixx57 = \frac{Continuous\ Limit}{Instaneous\ Limit}\ x32767\ xCos\left(30^\circ\right)$$

$$Ixx58\ \ = \frac{Ixx69^2\ - Ixx77^2\ - Ixx57^2}{32767^2} \times ServoFrequency(\ Hz\ ) \times Time(sec\ onds\ )$$

Based on the above data and equations, the following results: Ixx69=32767

Ixx57=11035

Ixx58=4004

For details about I^2T protection, refer to the safety sections of the User Manual. Details about the variable setup can be found in the Software Reference manual.

CALCULATING MINIMUM PWM FREQUENCY

The minimum PWM frequency requirement for a system is based on the time constant of the motor. Calculate the minimum PWM frequency to determine if the amplifier will properly close the current loop. Systems with very low time constants need the addition of chokes or in-line inductive loads to allow the PMAC to properly close the current loop of the system. In general, the lower the time constant of the system, the higher the PWM frequency must be.

Calculate the motor time constant by dividing the motor inductance by the resistance of the phases.

$$\tau_{motor} = \frac{L_{motor}}{R_{motor}}$$

The relationship used to determine the minimum PWM frequency is based on the following equation:

$$\tau > \frac{20}{2\pi \times PWM(Hz)}$$

$$\therefore PWM(Hz) = \frac{20}{2\pi\tau}$$

Example:

L_{motor} = 5.80 mH

R_{motor} = 11.50 Ω

$$\tau_{motor} = \frac{5.80mH}{11.50\Omega} = 0.504m\,sec$$

Therefore, $PWM(Hz) = \frac{20}{2\pi \times (0.504m\,sec)}$ = 6316 Hz

Based on this calculation, set the PWM frequency to at least 6.32kHz.

TROUBLESHOOTING

Error Codes

In most cases, the GEO Drive communicates error codes with a text message via the serial port to the host. Some error codes are also transmitted to the Status Display. The same message is saved in the EEPROM under an error history log (FLTHIST, ERR) so nothing is lost when power is removed. Not all errors reflect a message back to the host. In these cases, the no-message errors communicate only to the Status Display.

The response of the GEO Drive to an error depends on the error's severity. There are two levels of severity:

1. Warnings (simply called errors and not considered faults and do not disable operation).
2. Fatal errors (fatal faults that disable almost all drive functions, including communications).

Note

The GEO Drive automatically disables at the occurrence of a fault.

PWM Status Display Codes

The 7-segment display on the current model provides the following codes:

Display	Description	Cause
0	Normal Operation	
1	Time Based Over Current on Axis 1	An internal timer has noticed that Axis 1 is taking more RMS current than the drive was designed to produce. Reduce loading.
2	Over Current – Axis 1.	Over Current sensors have detected an excess of current through the motor leads. Typically, a shorted motor, shorted cable, extremely excessive current, or voltage commands from the controller through the power stage. The controller is the PMAC controller.
3	PWM Over Frequency Axis 1	PMAC or UMAC setup is incorrect. The I-variables for the phase clock frequency and PWM frequencies should be adjusted to under 16 kHz.
4	Power Stage Over Temp Axis 1.	Heat sink temperature is above a factory pre-set range (approximately 75 ºC). Drawing excessive current through the amplifier, blocked airflow through the amplifier or operation in an ambient temperature above 45 ºC.
5	Motor Over Temp Axis 1	Normally-closed input on the front of the GEO drive amplifier connector X3 is detected in open circuit between pins 3 and 4.
6	Over Current – Axis 2.	Over Current sensors have detected an excess of current through the motor leads. An internal timer has noticed that Axis 2 is taking more RMS current than the drive was designed to produce. Reduce loading.
7	Over Current Axis 2.	Over Current sensors have detected an excess of current through the motor leads. Typically, a shorted motor, shorted cable, extremely excessive current, or voltage commands from the controller through the power stage. The controller is the PMAC controller.
8	PWM Over Frequency Axis 2	PMAC or UMAC setup is incorrect. The I-variables for the phase clock frequency and PWM frequencies should be adjusted to under 16 kHz.
9	Heat Sink Over Temp Axis 2.	Heat sink temperature is above a factory pre-set range (approximately 75 ºC). Drawing excessive current through the amplifier, blocked airflow through the amplifier or operation in an ambient temperature above 45 ºC.

A	Motor Over Temp Axis 2	Normally-closed input on the front of the GEO drive amplifier connector X3 is detected in open circuit between pins 3 and 4.
B	Over Voltage.	The bus voltage has exceeded a factor pre-set threshold of 820V for 480V drives or 420V for 230V drives. Lack of ability to dump the regenerated energy from the motor. A shunt regulator or dump resistor can help GAR 49 or GAR78. Another common cause can be excessively high input line voltage.
C	Under Voltage	The DC bus internal to the GEO drive has decreased below a factory pre-set threshold of 16 to 30Vdc (no AC input power to the drive).
D	Shunt Regulator Fault	Fatal fault where the internal drive electronics for the power stage that controls the shunt regulator has failed. If unable to reset this fault, the unit needs to be returned to the factory for repair. A short in the shunt regulator or motor leads can cause this fault code. The output drive transistors have gone into a linear mode instead of a switching mode (DSAT).
E	Ground Fault	A short in the shunt regulator or motor leads can cause this fault code. The output drive transistors have gone into a linear mode instead of a switching mode (DSAT).
F	Gate Drive Power Fault	Fatal fault where the internal drive electronics for the power stage that controls the six IGB outputs has failed. If unable to reset this fault, the unit needs to be returned to the factory for repair. A short in the shunt regulator or motor leads can cause this fault code. The output drive transistors have gone into a linear mode instead of a switching mode (DSAT).

Status Display

Status Display	Color	Direct PWM	MACRO	Description
7-segment LED	Red	Standard	Standard	16 numeric codes plus two decimal points
Enable 1 LED	Green/Red	Standard	Standard	Green when first axis enabled. Red when drive is not enabled. (Unlit does not necessarily mean fault.)
Enable 2 LED	Green/Red	Standard for 2-axis	Standard for 2-axis	Green when second axis enabled. Red when drive is not enabled. (Unlit does not necessarily mean fault.)
DC bus LED	Red	Standard	Standard	Lit when bus powered.
Shunt LED	Yellow	Standard	Standard	Lit when drive is attempting to dump power through the external shunt regulator regen resistor.
+5V LED	Green	Standard	Standard	Lit when 5V logic has power.

APPENDIX A

Motor Cable Information

Cable sets (motor and feedback) can be purchased directly from Delta Tau Data Systems, Inc., to provide a complete plug-n-play system. Available cables are listed below.

UMAC Accessories	OPT-5A	Amplifier PWM Cable, 600 mm (24 inches) long, mini-D 36 conductor, 1per axis	200-602739-024x
UMAC Accessories	OPT-5B	Amplifier PWM Cable, 900 mm (36 inches) long, mini-D 36 conductor, 1per axis	200-602739-036x
UMAC Accessories	OPT-5C	Amplifier PWM Cable, 1.5 m (60 inches) long, mini-D 36 conductor, 1per axis	200-602739-060x
UMAC Accessories	OPT-5D	Amplifier PWM Cable, 1.8 m (72 inches) long, mini-D 36 conductor, 1per axis	200-602739-072x
UMAC Accessories	OPT-5E	Amplifier PWM Cable, 2.1 m (84 inches) long, mini-D 36 conductor, 1per axis	200-602739-084x
UMAC Accessories	OPT-5F	Amplifier PWM Cable, 3.6m (144 inches) long, mini-D 36 conductor, 1per axis	200-602739-144x

However, for those who wish to manufacture their own cable sets, this appendix provides pin-out information between the GEO Drive's power and feedback connections and the motor receptacles for most motor products.

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REVISIONS				
REV.	DESCRIPTION	DATE	CHGD	APPROVED
--	NEW DRAWING RELEASE	11-26-02	N.G.	BILL K.

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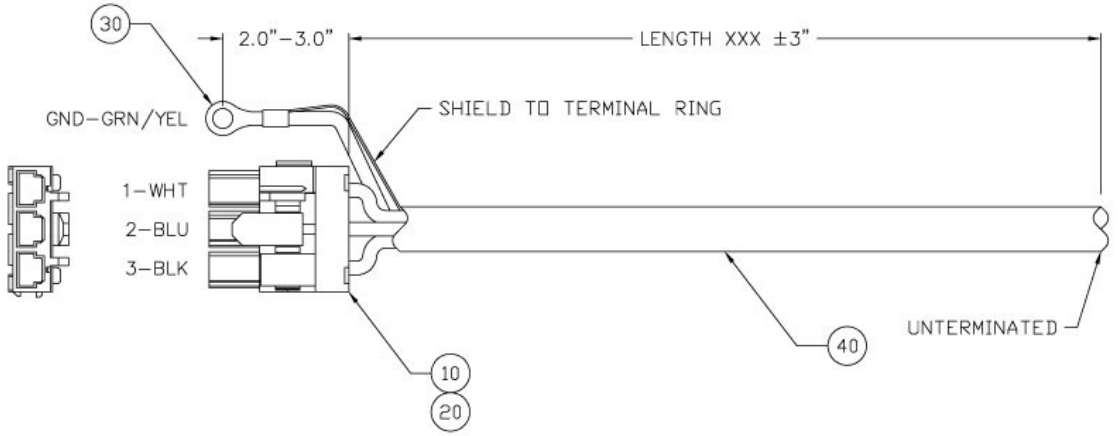
-0200	20 FEET



NOTES: UNLESS OTHERWISE SPECIFIED

1. PART NOS. ARE INTERPRETED AS FOLLOWS: THE FIRST 3 DIGITS OF THE SUFFIX DENOTES LENGTH AND THE LAST DIGIT OF THE SUFFIX DENOTES REVISION LEVEL. ALL LENGTHS ARE SPECIFIED IN INCHES.

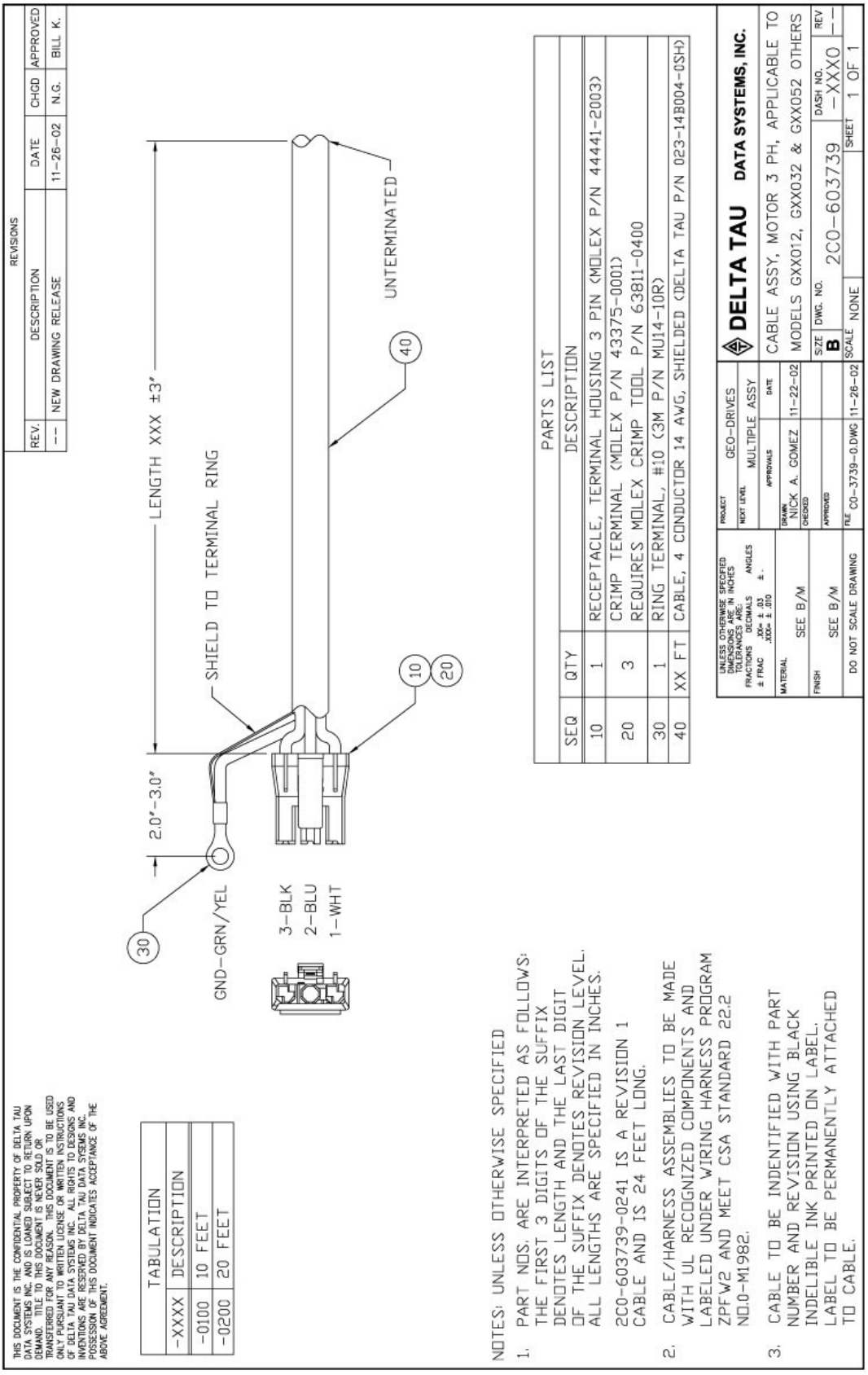
   2C0-603738-0241 IS A REVISION 1 CABLE AND IS 24 FEET LONG.

2. CABLE/HARNESS ASSEMBLIES TO BE MADE WITH UL RECOGNIZED COMPONENTS AND LABELED UNDER WIRING HARNESS PROGRAM ZPFW2 AND MEET CSA STANDARD 22.2 NO.0-M1982.

3. CABLE TO BE INDENTIFIED WITH PART NUMBER AND REVISION USING BLACK INDELIBLE INK PRINTED ON LABEL. LABEL TO BE PERMANENTLY ATTACHED TO CABLE.

PARTS LIST		
SEQ	QTY	DESCRIPTION
10	1	RECEPTACLE, TERMINAL HOUSING 3 PIN (MOLEX P/N 42816-0312)
20	3	CRIMP TERMINAL (MOLEX P/N 42815-0031) REQUIRES MOLEX CRIMP TOOL P/N 63811-1500
30	1	RING TERMINAL, #10 (3M P/N MU14-10R)
40	XX FT	CABLE, 4 CONDUCTOR 14 AWG, SHIELDED (DELTA TAU P/N 023-14B004-0SH)

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS ± FRAC, DECIMALS .XX= ± .03, .XXX= ± .010, ANGLES ± .	PROJECT	GEO-DRIVES	DELTA TAU DATA SYSTEMS, INC.
	NEXT LEVEL	MULTIPLE ASSY	CABLE ASSY, MOTOR 3 PH, APPLICABLE TO MODELS GXX101, GXX151 & OTHERS
	APPROVALS	DATE	
MATERIAL: SEE B/M	DRAWN: NICK A. GOMEZ	11-22-02	SIZE: B; DWG. NO.: 2C0-603738; DASH NO.: -XXX0; REV: --
	CHECKED		
FINISH: SEE B/M	APPROVED		SCALE: NONE; SHEET: 1 OF 1
DO NOT SCALE DRAWING	FILE: C0-3738-0.DWG	11-26-02	


REVISIONS
REV. | DESCRIPTION | DATE | CHGD | APPROVED
-- | NEW DRAWING RELEASE | 11-26-02 | N.G. | BILL K.
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TABULATION
-XXXX | DESCRIPTION
-0100 | 10 FEET
-0200 | 20 FEET
30
2.0"-3.0"
LENGTH XXX ±3"
SHIELD TO TERMINAL RING
GND-GRN/YEL
3-BLK
2-BLU
1-WHT
10
20
40
UNTERMINATED
NOTES: UNLESS OTHERWISE SPECIFIED
1. PART NOS. ARE INTERPRETED AS FOLLOWS: THE FIRST 3 DIGITS OF THE SUFFIX DENOTES LENGTH AND THE LAST DIGIT OF THE SUFFIX DENOTES REVISION LEVEL. ALL LENGTHS ARE SPECIFIED IN INCHES. 2CO-603739-0241 IS A REVISION 1 CABLE AND IS 24 FEET LONG.
2. CABLE/HARNESS ASSEMBLIES TO BE MADE WITH UL RECOGNIZED COMPONENTS AND LABELED UNDER WIRING HARNESS PROGRAM ZPFW2 AND MEET CSA STANDARD 22.2 NO.0-M1982.
3. CABLE TO BE INDENTIFIED WITH PART NUMBER AND REVISION USING BLACK INDELIBLE INK PRINTED ON LABEL. LABEL TO BE PERMANENTLY ATTACHED TO CABLE.
PARTS LIST
SEQ | QTY | DESCRIPTION
10 | 1 | RECEPTACLE, TERMINAL HOUSING 3 PIN (MOLEX P/N 44441-2003) CRIMP TERMINAL (MOLEX P/N 43375-0001) REQUIRES MOLEX CRIMP TOOL P/N 63811-0400
20 | 3
30 | 1 | RING TERMINAL, #10 (3M P/N MU14-10R)
40 | XX FT | CABLE, 4 CONDUCTOR 14 AWG, SHIELDED (DELTA TAU P/N 023-14B004-0SH)
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS ± FRAC .XX± ± .03 .XXX± ± .010 ANGLES ± .
MATERIAL SEE B/M
FINISH SEE B/M
DO NOT SCALE DRAWING
PROJECT GEO-DRIVES
NEXT LEVEL MULTIPLE ASSY
APPROVALS DATE
DRAWN NICK A. GOMEZ 11-22-02
CHECKED
APPROVED
FILE CO-3739-0.DWG 11-26-02
DELTA TAU DATA SYSTEMS, INC.
CABLE ASSY, MOTOR 3 PH, APPLICABLE TO MODELS GXX012, GXX032 & GXX052 OTHERS
SIZE B
DWG. NO. 2CO-603739
DASH NO. -XXXO
REV --
SCALE NONE
SHEET 1 OF 1

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REVISIONS				
REV.	DESCRIPTION	DATE	CHGD	APPROVED
--	NEW DRAWING RELEASE	11-27-02	N.G.	BILL K.

TABULATION	
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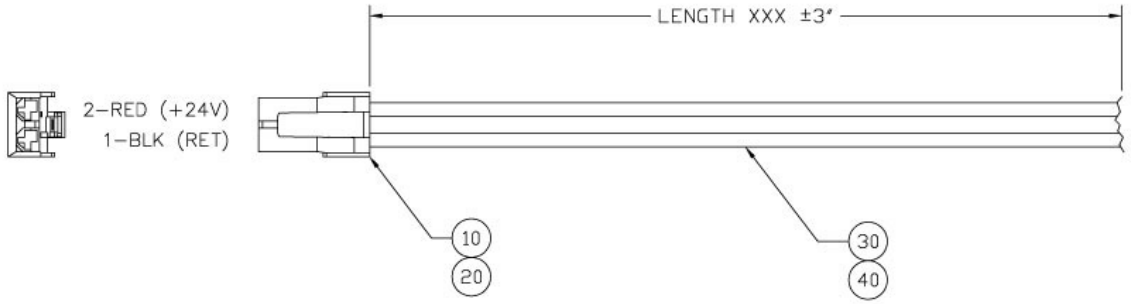

NOTES: UNLESS OTHERWISE SPECIFIED

1. PART NOS. ARE INTERPRETED AS FOLLOWS: THE FIRST 3 DIGITS OF THE SUFFIX DENOTES LENGTH AND THE LAST DIGIT OF THE SUFFIX DENOTES REVISION LEVEL. ALL LENGTHS ARE SPECIFIED IN INCHES.

   2C0-603752-0241 IS A REVISION 1 CABLE AND IS 24 FEET LONG.

2. CABLE/HARNESS ASSEMBLIES TO BE MADE WITH UL RECOGNIZED COMPONENTS AND LABELED UNDER WIRING HARNESS PROGRAM ZPFW2 AND MEET CSA STANDARD 22.2 NO.0-M1982.

3. CABLE TO BE INDENTIFIED WITH PART NUMBER AND REVISION USING BLACK INDELIBLE INK PRINTED ON LABEL. LABEL TO BE PERMANENTLY ATTACHED TO CABLE.

PARTS LIST		
SEQ	QTY	DESCRIPTION
10	1	RECEPTACLE, TERMINAL HOUSING 2 PIN (MOLEX P/N 44441-2002)
20	2	CRIMP TERMINAL (MOLEX P/N 43375-0001) REQUIRES MOLEX CRIMP TOOL P/N 63811-0400
30	XX FT	WIRE, BLACK 12 AWG, (ANIXTER P/N 1015-12/65-0)
40	XX FT	WIRE, RED 12 AWG, (ANIXTER P/N 1015-12/65-2)

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS ± FRAC, DECIMALS .XX= ± .03, .XXX= ± .010, ANGLES ± .	PROJECT	GEO-DRIVES	DELTA TAU DATA SYSTEMS, INC.
	NEXT LEVEL	MULTIPLE ASSY	CABLE ASSY, 24 VDC INPUT, APPLICABLE TO ALL MODELS
	APPROVALS	DATE	
MATERIAL SEE B/M	DRAWN NICK A. GOMEZ	11-27-02	SIZE B, DWG. NO. 2C0-603752, DASH NO. -XXX0, REV --
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FINISH SEE B/M	APPROVED		
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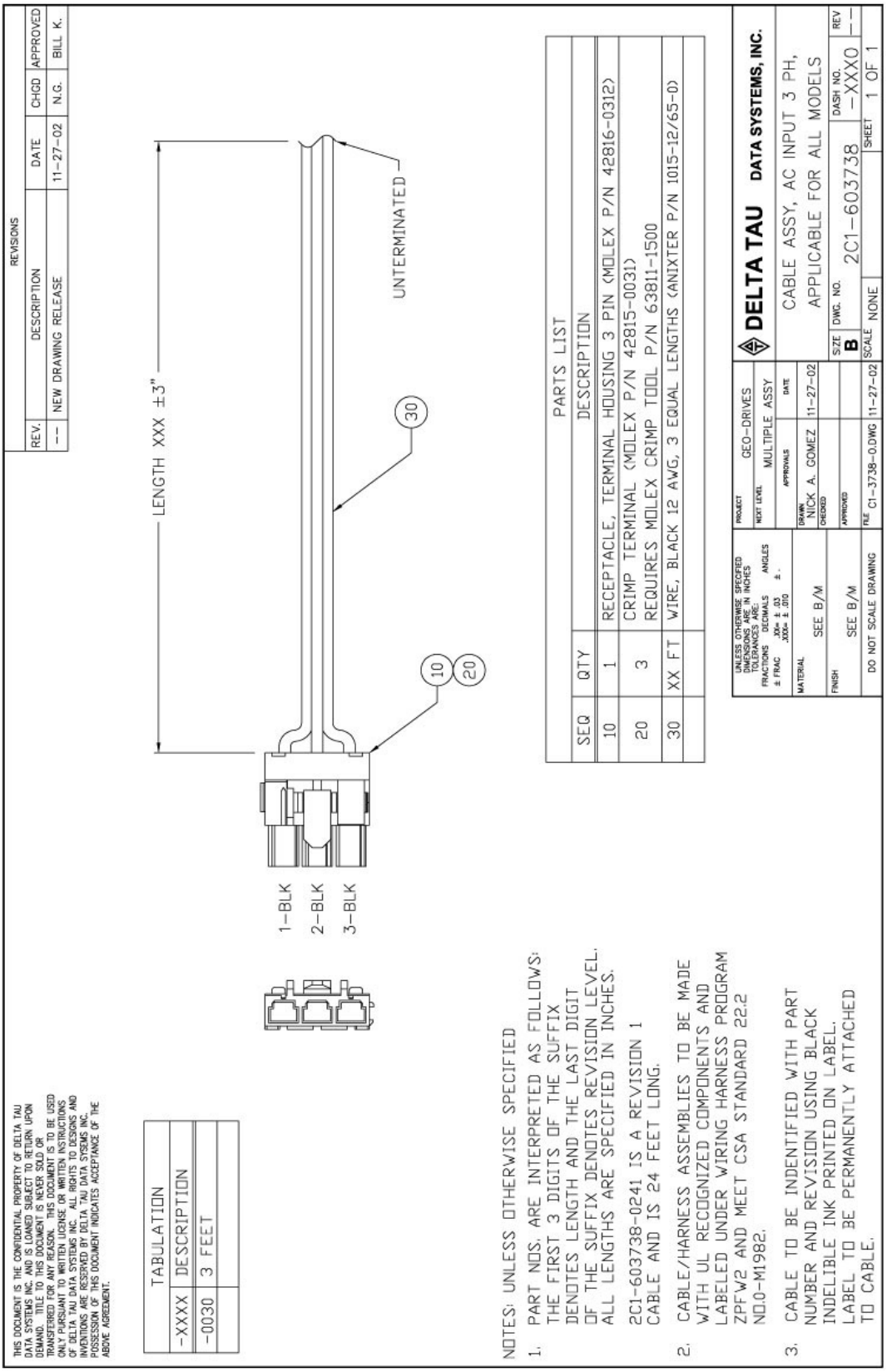
REVISIONS
REV. | DESCRIPTION | DATE | CHKD | APPROVED
-- | NEW DRAWING RELEASE | 11-27-02 | N.G. | BILL K.
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TABULATION
-XXXX | DESCRIPTION
-0030 | 3 FEET
LENGTH XXX ±3"
UNTERMINATED
30
10
20
1-BLK
2-BLK
3-BLK
PARTS LIST
SEQ | QTY | DESCRIPTION
10 | 1 | RECEPTACLE, TERMINAL HOUSING 3 PIN (MOLEX P/N 42816-0312)
20 | 3 | CRIMP TERMINAL (MOLEX P/N 42815-0031) REQUIRES MOLEX CRIMP TOOL P/N 63811-1500
30 | XX FT | WIRE, BLACK 12 AWG, 3 EQUAL LENGTHS (ANIXTER P/N 1015-12/65-0)
NOTES: UNLESS OTHERWISE SPECIFIED
1. PART NOS. ARE INTERPRETED AS FOLLOWS: THE FIRST 3 DIGITS OF THE SUFFIX DENOTES LENGTH AND THE LAST DIGIT OF THE SUFFIX DENOTES REVISION LEVEL. ALL LENGTHS ARE SPECIFIED IN INCHES.
2C1-603738-0241 IS A REVISION 1 CABLE AND IS 24 FEET LONG.
2. CABLE/HARNESS ASSEMBLIES TO BE MADE WITH UL RECOGNIZED COMPONENTS AND LABELED UNDER WIRING HARNESS PROGRAM ZPFW2 AND MEET CSA STANDARD 22.2 NO.0-M1982.
3. CABLE TO BE INDENTIFIED WITH PART NUMBER AND REVISION USING BLACK INDELIBLE INK PRINTED ON LABEL. LABEL TO BE PERMANENTLY ATTACHED TO CABLE.
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS ± FRAC DECIMALS .XX= ± .03 .XXX= ± .010 ANGLES ±
MATERIAL SEE B/M
FINISH SEE B/M
DO NOT SCALE DRAWING
PROJECT GEO-DRIVES
NEXT LEVEL MULTIPLE ASSY
APPROVALS DATE
DRAWN NICK A. GOMEZ 11-27-02
CHECKED
APPROVED
FILE C1-3738-0.DWG 11-27-02
DELTA TAU DATA SYSTEMS, INC.
CABLE ASSY, AC INPUT 3 PH, APPLICABLE FOR ALL MODELS
SIZE B
DWG. NO. 2C1-603738
DASH NO. -XXX0
REV --
SCALE NONE
SHEET 1 OF 1